Working in confined spaces – here's how to keep the risk in check

Understanding and mastering the risks involved makes working in confined spaces, tanks and containers a safe job. Seamless risk assessment is essential here. This is the best way to avoid accidents and even death.

Accidents in confined spaces – why do they happen?

Loss of consciousness due to a lack of oxygen, poisoning due to inhalation of toxic gases, burning due to explosions, or falls from great heights – these are among the most frequent accident situations while working in confined spaces. According to the Bureau of Labor Statistics, in 2015, 136 people in the USA alone died in accidents when working in confined spaces and containers.[1]

For this reason, entering confined spaces requires very special precautions and regulations worldwide. Many countries have strict rules with regard to planning and execution of work in confined spaces. OSHA[2] regulation 29 CFR 1910.146[3] applies in the USA. In Germany, DGUV[4] regulation 113-004 part 1[5] extensively outlines applicable regulations and precautions.

This also includes the obligation to complete a risk assessment and to create a permit. Furthermore, the supervisors and the workers completing tasks in confined spaces should be explicitly trained and certified. This begs the justified question: So why do so many, partly fatal, accidents still happen? What goes wrong in these situations?

The answers are diverse: Sometimes, the lack of an adequate risk assessment means that the work location has not even been classified as a confined space with all the hazards that can occur. After all, recognising a tank as a possible confined space should be relatively easy. But what about bottlenecks and angles in larger, and apparently less risky spaces? If a confined space is not recognised as such, the accompanying safety measures are also very likely to have been omitted.

Another typical cause: There is a risk assessment, but no valid work-permit providing information immediately prior to entry detailing the dangers that exist at the moment. Or the employee is not adequately trained for working in the confined space – but he is nevertheless ordered by his superior to complete the task.

Approximately **200** people worldwide die each year from the effects of an accident in a confined space.[6]

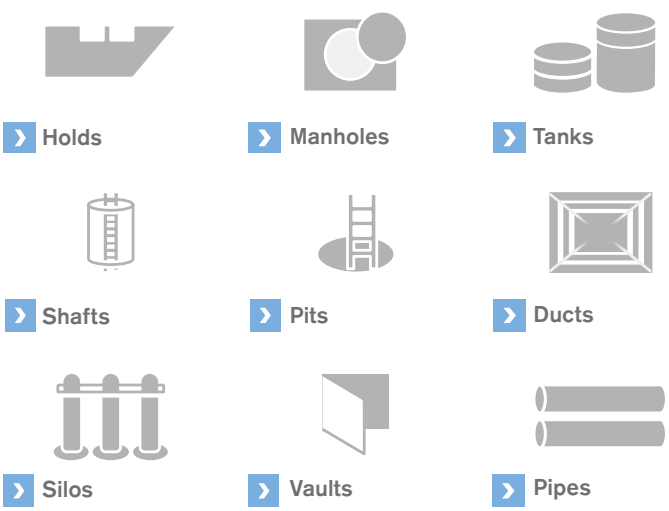
57 % of all employers surveyed within the scope of an American project (California) did not have an emergency plan for rescue out of a confined space.[7]

2/3 of these accidents were caused by a toxic atmosphere, which was already present in 70% of the cases of the areas entered.[8]

24 % of these accidents happened during maintenance, followed by cleaning work (12%) and inspections (11%).[9]

The following graphic shows how diverse the understanding of confined spaces can be in the working world. Not only are there obvious examples like tanks and columns, but also shafts, pits, tunnels, chambers, and tubes. All of them can be deadly.

Examples of confined spaces



What is the difference between "danger" and "risk"?

In order to complete a risk assessment for specific work processes, it's important at the start to know the formal difference between a "danger" and a "risk".

"Dangers" are all aspects and framework conditions that could have a threatening influence on people, the environment, and plant safety with regard to a specific work situation. "Risk", on the other hand, is understood by work safety experts as the evaluation of the probability that this danger will occur in this exact situation. This describes the specific potential of a hazard. An example: Acid has been stored in a tank that could lead to chemical burns in the event of skin contact or inhalation. This represents a potential danger to the worker who is expected to access the tank for maintenance work. However, the tank has already been thoroughly purged and ventilated, which means that the probability and therefore risk of skin and lung damage to the worker is close to zero.

HAZARDS AND RISKS OF CONFINED SPACES

DANGERS

Combustible gases and vapours

Toxic fluids and gases like chlorine (Cl_2), ammonia (NH_3), hydrochloric acid (HCl)

Toxic organic substances (especially benzene, methane, ethylene, butadiene)

Particles (especially breathable)
Additional dangers and risks during specific work processes

RISKS

Explosions, triggered by sparks or high temperatures

Explosions due to the instable behaviour of substances

Serious damage due to toxic gases, vapours, or fluids in case of inhalation or skin contact

Contact with caustic hazardous substances

Serious damage due to carcinogens or gamete-damaging long-term effects of certain toxic substances

Uncontrolled reactions of chemical substances in case of contact with certain catalysts

What is the sense and purpose of the risk assessment?

The goal of the risk assessment is to list all of the dangers present at this work location and to evaluate their scope – i.e. their risk. This results in measures that may be used to help prevent, reduce or control these dangers. It also includes the definition of rescue scenarios.

Safety officers should also consult system and production plans for the evaluation process. These can provide specific references to structural features and potential dangers due to production residues. It is also the task of the safety officers to think about the individual, specific planned work processes and to anticipate possible risks – for example, the potential development of an explosive atmosphere by adding solvents to a sealing paint.

It is important to precisely analyse step-by-step which person or persons could be threatened by a specific danger and which working methods and information in the permission certificate or which personal protective equipment ensure safe entry and exit.

All of the knowledge resulting from the risk assessment must be documented and shared with the supervisor, the safety guard, and the relevant worker before starting the task. The risk assessment should also be regularly checked and revised as necessary and updated – ideally within defined intervals, but at least once annually.

How can specific dangers be identified and risks assessed?

The safety officer first needs to get an overview of the actual situation: What is the container (tank, silo, etc.) used for? What hazardous substances might it contain? What type of hazardous substances are they – caustic, corrosive, radioactive? Is it extremely hot or cold inside? Is there a lack of oxygen or danger of explosion? Are there mechanical dangers like active hydraulic systems or is there a danger of being engulfed by the contents, e.g. because a fine-grain granulate is present in the container?

A rating model is useful for risk assessment: The safety officer lists all of the possible dangers. He checks which persons are exposed to a risk and which control mechanisms are already available. Next, the scope of the danger is assessed on a scale from 1 to 8. The risk results from weighting the scope of danger with its probability of occurring on a scale of 1 to 8. After this, the control mechanisms are checked in terms of effectiveness and expanded as needed.

Dräger

FORM FOR HAZARD ASSESSMENT :

Date: _____ Time: _____

Dangers:	Endangered person:	Existing control mechanisms:	Level of severity (S): 1 – 8	Probability (P): 1 – 8	Results (S x P)	Risk	Are the existing control mechanisms sufficient?	If NO, additional control mechanisms to reduce the risk:

Factors in severity level (S)	Factors in probability (P)
1 = No injury	1 = Will not occur
2 = Light (only first aid necessary)	2 = Not likely to occur
3 = Light injury (up to 3 days work loss)	3 = Very improbable
4 = Moderate injury (3 days up to 1 month work loss)	4 = Improbable
5 = Serious injury (over 1 month work loss)	5 = Probable
6 = Serious injury (permanently incapable of working)	6 = Very probable
7 = Death	7 = Highly probable occurrence
8 = Multiple cases of death	8 = Will occur

Probability (P)

Severity (S) \ X	8	7	6	5	4	3	2	1
8	64	56	48	40	32	24	16	8
7	56	49	42	35	28	21	14	7
6	48	42	36	30	24	18	12	6
5	40	35	30	25	20	15	10	5
4	32	28	24	20	16	12	8	4
3	24	21	18	15	12	9	6	3
2	16	14	12	10	8	6	4	2
1	8	7	6	5	4	3	2	1

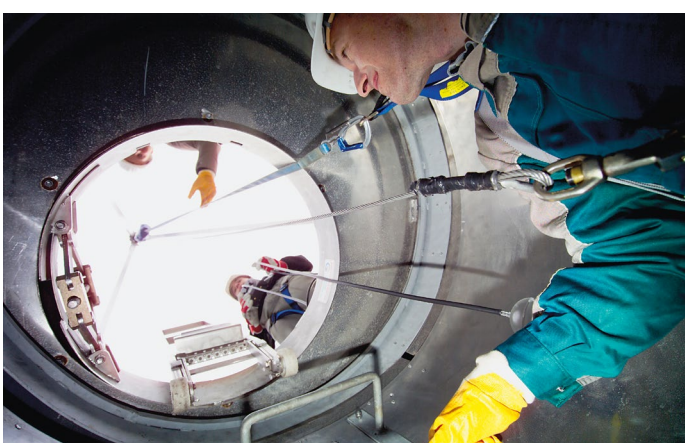
Risk

- **1 – 9: Tolerable** — No action required – observe
- **10 – 19: Moderate** — Satisfactory – low risk
- **20 – 29: High** — Unsatisfactory – immediate action required
- **30 – 64: Very high** — Unacceptable – immediate action

Download the complete form here.

How can a "safe system of work" be successful?

The conventional hierarchy of measures in occupational safety helps with the creation of work processes, i.e. the "safe system of work". This involves specifying methods and procedures that need to be implemented at a practical level. The goal of the "safe system of work" is to minimise permanently the risks of specific work processes.



FIVE PARTIAL STEPS ON THE PATH TO THE "SAFE SYSTEM OF WORK":

1. Avoidance of risks via elimination of the task
2. Substitution by less dangerous or harmless processes
3. Isolation of the danger via preventative interaction in the process (shut off mechanical functions, disconnect the power supply, ventilation, etc.)
4. Accompanying control measures (pre-entry measurement of toxic or explosive gases, evaluation of entry options, monitoring of occupational exposure limits and exposure times, comparison with permission certificate, etc.)
5. Use of personal protective equipment such as self-contained breathing apparatus, filter devices, chemical protection suits, and communication systems

A "safe system of work" includes regulations for supervisors, for the necessary training of all participants, for access rules and obligatory pre-tests, for the provision and selection of tools and protective equipment, for the preparation of emergency measures, for communication channels, and finally for continuously monitoring adherence to the processes and measures.

An example of an effective measure for permanently reducing risks when entering confined spaces is the selection of the correct gas measurement process, the right gas detection device, and the matching sensor. This must be suitable for pre-entry measurement of the space with regard to the specific toxic or explosive gases that normally occur there. The pre-entry measurement and the detailed measurement results must be documented on the permission certificate.

During the selection of personal protective equipment, other requirements must be taken into consideration, such as the suitability of the equipment for use in explosion-prone areas. The selection of respiratory protection requires knowledge of the necessary protection factor and the type of air supply.

Please note: Conditions in a confined space like a container or a tank can change during the work process! Continuous monitoring of the atmosphere on the inside is therefore immensely important!

What is the function of the permission certificate?

The permission certificate is normally an important component of the "safe system of work".
Work permissions are essential for potentially health-endangering work and any high-risk work that is not routine and does not form part of the production process. Such a permit formalises and documents the communication between the plant management, the supervisor, and the relevant worker. This is especially important when contractors complete work, since clear information makes communication easier. Finally, the permission certificate must be integrated in the company's internal monitoring and auditing system.

The permit includes:

- Description, location, and environment of the work; warning of possible dangers
- Authorisation rules and responsibilities (issuer and recipient of the document)
- Emergency plan
- Confirmation of training of the person who intends to complete the work (especially relevant if contractors are employed)

CONCLUSION: WHAT ARE THE KEY FACTORS INVOLVED?

Theory is just one part of it. The transfer of theory into practice is also important.

Here is a summary of the most important aspects:

- The processes to be followed and the choice of equipment must be tailored to suit the respective workplace and the task. They need to be adhered to at all times.
- The risk assessment must be completed again if work or environmental conditions or regulations change, since a danger or a risk may be changed by this.
- For regularly recurring tasks of a similar type, instruction of the participants must take place at regular intervals and at least once a year.
- If a workplace is rated as a confined space within the scope of a risk assessment and all dangers have been evaluated, this rule always applies: Prior to entering a tank, it must be measured correctly for clearance using a suitable measurement strategy.
- Even after the pre-entry measurement, the atmosphere needs to be monitored constantly, depending on the danger, for a lack of oxygen or for explosive or toxic substances.

The permission certificate itself does not make the work safer. It also depends on ensuring that the employee who will be undertaking the work is familiar with and understands all of the points indicated on the permission certificate. Does he know, for example, which precautions must be taken? And which equipment can save his life in case of doubt?

Sometimes, the risks documented on the permission certificate are not taken seriously enough. Employees may tend to rely on their senses and trust that nothing can happen. But: Many toxic or even deadly hazardous substances cannot be perceived by the senses alone. And once the employee is inside the tank, it may become clear how dangerous this situation could be for him, but by then he may already be incapable of action, unconscious – or dead. Anyone who panics and tries spontaneously to rescue an injured person in this kind of atmosphere without adequate respiratory protection also exposes himself to mortal danger. For this reason, a safety guard is required for every work process in confined spaces, and an emergency plan must always be established.

Identifying hazards and professionally analysing risks makes it possible to choose the right solution to reduce or even completely eliminate the risks. This can all be learned: The right training and workshops offer practical courses in evaluation, work, and materials selection processes, which can then be put into practice as needed.

SOLUTIONS FOR SAFE WORK IN CONFINED SPACES

- Professional risk assessment
- Risk-minimised design of work organisation/processes
- Inerting, ventilation, purging confined spaces
- Pre-entry measurement according to work permit
- Safety guard on duty during entry
- Continuous gas monitoring
- Safe use and maintenance of PPE
- Training and supervision of work processes
- Training for rescue scenarios

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SOURCES:

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